Nettle Fibers as a Potential Natural Raw Material for Textile in Latvia

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Abstract **– In Europe, attention is devoted to the methods of obtaining nettle fibers for technical textiles. Several new nettle plant clones have been created. From wild nettles they differ in the higher number of fibers. The nettle can be grown for 10 – 15 years in one place without much care.**

The wild nettle grows in Latvia very well. Therefore, the task has been to determine the possibility of cultivating nettle in Latvia for fiber needs. It has been determined that the obtained yield of fiber is less than that of flax and hemp. Experimental results have shown that the bast content in nettle straws is approximately 20%. Average fiber strength is similar to that of flax and hemp fiber – 33-58 cN/tex. It has been also determined that from older plants more fibers can be obtained and they are even stronger. The increase in the plant spacing distance not only decreases the number of nettle fibers but also their mechanical properties.

Keywords **– nettle, Urtica dioica L., nettle fiber, fiber production, fiber strength, renewable resources, fiber quality**

I. Introduction

In Europe, people have been using wild nettle plants to obtain fiber already since the 12th century [1]. Especially they were used in times of political or economic crises. Mostly domestic handcraft textiles were produced from these fibers.

The first attempt to commercialise the production of nettle fibers was in Germany at the beginning of the 18th century, but serious research in the cultivation was started in the 19th century, but it was not very successful. Only from 1927 to 1950 Dr. Gustav Bredemann selected plants of Urtica dioica and produced several high fiber clones that could be cultivated [2]. The criteria for selecting the plants were that they should be frostresistant, have long, straight stems with minimal branching and high percentage of fiber in the stem.

During the World War I and World War II, nettle fibers were used instead of cotton. In the 1940s, about 500 ha of nettles were cultivated in Germany and Austria for fiber production [1, 3]. After World War II, nettle fibers were forgotten because of chemical fiber boom, which was much cheaper, as well as its processing was easier.

The research on nettle clones was started again in the 1990s in Germany, Austria and Finland [1]. Nowadays this interest is related to:

- the wish to decrease toxic residues in textiles because of the negative impact on health and requirement for the conventional unsustainable textile fibers;
- positive experiences and an increasing demand for textiles made of organic cotton, flax and hemp;
- development of new fiber materials that can increase the supply of organically grown domestic fibers in addition to flax and hemp;
- possibility to transform a common wild plant into commercially profitable;
- usage of all plant parts in different industrial branches (for example, industrial materials, cosmetics, food industry, pharmacy, farming) as it is for hemp (Cannabis sativa L.).

In the stems of the wild nettle plants, there are about 4 – 5% of fibers, but in cultivated species it can reach 17 – 18%. Research in such countries as Germany, Austria, Finland, the UK, Italy, the Netherlands has shown that it is possible to obtained nettle stalk dry matter from 2.3 to 9.7 t/ha [1]. Fiber yield depends on the plant age. In the first year it is very low; in second year it is from 335 to 411 kg/ha, but in the third year it already ranges from 743 to 1016 kg/ha [4].

There is an opinion that nettle can be grown for 10 – 15 years. Austrian scientists C.R. Vogl and A.Hartl have mentioned [1] that nettle can give good fiber yields for 4 years. If it grows longer the number of weeds on the field increases and therefore fiber productivity decreases. It is interesting that the same scientists have mentioned that there is more fibers in the upper stem part and a lower percentage of woody core than in the lower part.

Likewise flax and hemp nettle fibers lie along the length of the stem beneath the surface of the outer bast layer. The main chemical composition elements are cellulose 79 - 83.5 %, hemicellulose 7.2 – 12.5 % and lignin 3.5 – 4.4 % [5].

The average fiber length varies from 43 to 58 mm, but the diameter from 19 to 50 µm [2, 5]. Italian scientists have determined that at the top of the stem the fibers are finer and longer [5].

Mean tensile strength of nettle fibers varies from 24 to 62 cN/tex, but elongation is slightly higher than 2%. The highest strength is for the fibers from the middle of the straw [5].

There is an interesting fact that fibers are very light. Specific weight of nettle fibers is 0.72 g/cm^3 [5], that is twice lower than that of cotton, hemp and flax (1.5 – 1.54g/cm^3).

The nettle fiber is the research object in many commercial projects in Europe and the main task is to develop technology to obtain nettles more successfully and cost effectively. At the same time the use of wild nettle is still also possible. In the territory of Latvia, there are two types of wild nettle plants: Urtica dioica, which grows in forests, near the rivers and settlements, where there is swampy and nitrates rich soil, and Urtica urens, which is a traditional weed in the gardens.

II. Materials and Methods

For the experiments, nettle fibres were used from the stems, which were obtained from the fields of Upyte Experimental Station of the Lithuanian Research Centre for Agriculture and Forestry on the August 15, 2011. The scientists of this centre have already been conducting the research on nettle clones for fiber production for several years. The nettles were planted in 2007 and 2008 at the different plant spacing. Densities of planted crops were 60 x 60 cm and 60 x 100 cm. Nettle planting process was described in the articles of the scientists from Upyte Research Station [4,6]. The stems for our research were cut from different field places. From each type of variations, samples were taken from front, middle and back of the field (later – 1st, 2nd and 3rd sector).

Obtained nettle stems were retted on the field for 10 days. After that they were dried in the room temperature for several weeks. Then the fibres were separated by hand. At first the bast part of the straw was separated. The obtained bast and wooden parts (sheaves) are shown in the Fig.1.

Fig. 1. Nettle bast and sheaves

After that the short fibers (fig. 2) were separated from the bast part of the straw.

Fig. 2. Nettle fibers

For the determination of tensile properties of the fibers, bundles with the length of 50 mm and mass of 0.75 mg ± 0.25 mg were prepared. The tensile properties were determined using Instron Universal Tester (Model 2519-107). During testing the initial length of the samples was 10mm. The fiber bundles were stretched at speed of 1 mm/min. Pretension was not applied.

III. Results and Discussion

In the experimental part of the work, following characteristics were determined:

- Sraw length;
- Bast content in the straws;
- Nettle fiber tensile properties.

The cut nettle stem length is summarized in the Table 1.

Table I

Average Nettle Straw Length (cm)

Sector	2007 60 x 60	2008 60 x 60	2008 60 x100
1st	144	137	158
2nd	100	108	181
3rd	106	116	124
Mean	116	120	154

It should be mentioned that straws were cut approximately 10 – 15 cm above the ground and therefore real straw length can be little higher than the obtained one.

In all three sectors, the straw length from the back of the field is less than from the front of the field. It can be explained by the fact that in the spring the back of the field and some of the middle part were under the water for a longer period.

The longest nettle straws were obtained from the three years old nettle plants (planted in 2008) at a spacing of 60 x 100cm between plants. The straw length in this case is longer by 28% in comparison with that planted in the same year, but at closer plant spacing 60 x 60 cm between plants; and by 33% longer than that planted one year earlier (2007).

It is very difficult to obtain fibers from the upper part of the nettle straws. For these purposes, approximately 80% of the straw length can be used. Therefore the upper parts, where stems are forked, were cut off. The final straw length was:

- 92cm when the planting spacing was 60 x 60cm;
- 133cm when the planting spacing was 60 x 100cm.

Bast content of different straws varies from 16 to 29%. Average values in different sectors are shown in Table II.

Table II

Bast Content (%) of Nettle

Sector	2007 60 x 60	2008 60 x 60	2008 60 x100
1.	22.6	20.4	19.7
2.	23.9	24.2	19.5
3.	19.7	23.8	21.7
Mean	22.1	22.8	20.3

Any relationship between the bast content and nettle planting year was not observed. However, it can be mentioned that bast content is influenced by the plant density. The less the plant density, the longer nettle straws are and the less the bast content is in them. The coefficient of variation of bast content in straws in different sectors and repeats was from 3.4 till 15.3%.

To evaluate the results of bast content for nettle straws, they were compared with the bast content of flax and hemp straws [7]. Dates were taken from the Agriculture Science Centre of Latgale which is located in the Baltic Region, where the tested nettle plants were grown. All dates were taken from year 2011. Thus, the influence of harvesting year and climatic conditions in different regions is minimized. Minimal and maximal results are shown in Table III. It should be mentioned that nettle plants have less bast content in comparison with flax and hemp.

TABLE III

BAST CONTENT (%) OF DIFFERENT PLANS HARVESTED IN BALTIC REGION

Plant	Minimal content	Maximal content
Nettle	16.6	27.0
Flax	26.7	34.4
Hemp	28.8	41.7

The results of fiber bundle mechanical characteristics are summarized in Table IV. The tensile strength of different fibers varies in a wide range – from 11 till 120 cN/tex. Average values are little higher than that ones determined in the scientific works of A. Hartl and C. R.Vogl [3,8]. They have determined that nettle fiber strength is from 28.2 to 36.8 cN/tex. They have also determined that the strength of the fibers increases with the growth time. The same tendency is observed in this research. The strength of the fibers taken from the four year old plants (2007) is by more than 30% higher in comparison with the strength of the three year old plants (2008).

The results show that strength of the fibers is influenced by plant spacing. The greater the spacing, the weaker fibers are. It can be explained by the branching of the plant, when it has plenty of space for it.

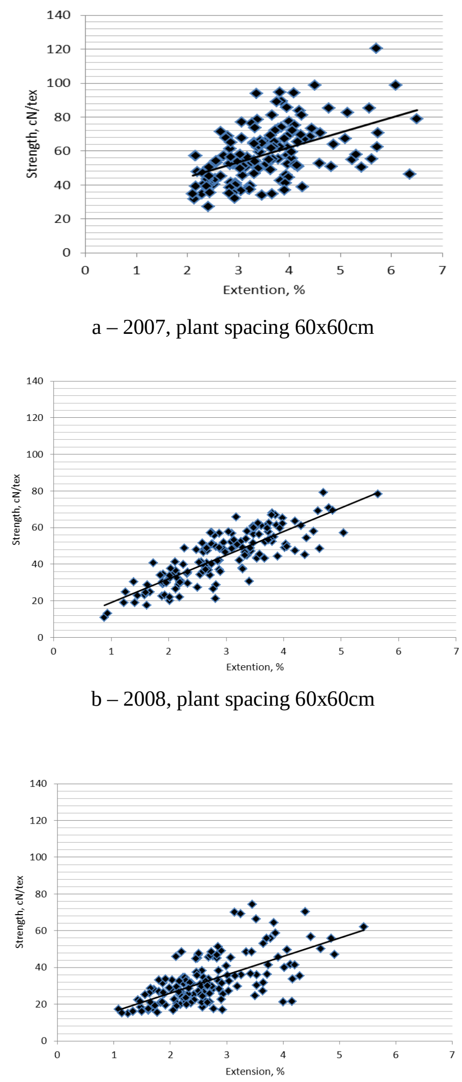
TABLE IV

NETTLE FIBER MECHANICAL CHARACTERISTICS

Planting year and distance	Sector	Extension at break (%)			Strength (cN/tex)		
		Range	Average	Coefficient of variation (%)	Range	Average	Coefficient of variation (%)
2007 60 x 60	1	2.2-6.5	3.9	27	27-120	68	30
	2	2.3-5.7	3.6	21	36-83	57	17
	3	2.1-4.6	3.0	22	32-75	50	23
	Mean	2.1–6.5	3.5	23	27-120	58	23
2008 60 x 60	1	1.9-5.6	3.4	26	27-79	49	23
	2	2.3-4.8	3.4	17	31-48	54	16
	3	0.9-3.3	2.1	27	11-49	30	27
	Mean	0.9-5.6	3.0	23	11-79	44	22
2008 60 x100	1	1.1-4.3	2.4	33	15-49	28	27
	2	1.4-5.4	3.2	28	22-74	46	27
	3	1.2-4.2	2.5	24	15-41	24	23
	Mean	1.1-5.4	2.6	28	15-74	33	26

Results of fiber extension have shown that average values are from 2.6 till 3.5%. They are little higher than in the previously mentioned works of A. Hartl and C. R.Vogl [3,8], where the values are in the range of 2.0 till 2.7%. This tendency and also high values the of the coefficient of variation can be explained by fiber uneven straightening during sample preparation. During sample preparation, small fiber bundles were seized in paper holders and it was very difficult to give one and the same preload during this process.

The deviations of strength and extension values of different fiber samples are given in Fig.3.



c – 2008, plant spacing 60x100cm

Fig. 3. Deviation of breaking characteristics

Gap of strength characteristics between fibers from different sectors can be explained by a long period of soil dampness in the spring.

CONCLUSIONS

Nettle fibers can be cultivated in Latvia and used for textile production. To obtain large number of fibers special nettle clones from Urtica dioica L should be used. The obtained yield of fiber is less than that of flax and hemp, but the nettle does not need planting every year. It can be grown for several years.

Experimental results of the work have shown and can be confirmed by literature data that:

- bast content in nettle straws is about 20% and it is less than in flax and hemp;
- fiber strength varies in a wide range and have greater unevenness;
- the longer the plant life, the stronger fibers can be obtained from them;
- it is not necessary to use the wide nettle plant spacing; it decreases the amount of bast content and strength of the fibers.

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Ilze Baltiņa, Lilita Lapsa, Zofija Jankauskiene, Elvīra Gruzdeviene. Nātru šķiedru kā tekstilizejmateriāla potenciālās audzēšanas iespējas Latvijā
Nātru šķiedras tekstiliju izgatavošanai lietotas jau izsenis. Galvenokārt tām uzmanība pievērsta krīžu un kara apstākļos, kad bijis citu izejvielu iztrūkums. Šodien zinātnieki no jauna pievēršas nātrei kā kultūraugam. Galvenokārt tas saistīts ar plašāku pieprasījumu tekstilrūpniecībā pēc bioloģiski sadalāmiem un otrreizēji pārstrādājamiem šķiedru materiāliem, kā arī sintētisko škiedrmateriālu sadārdzināšanos līdz ar naftas krājumu samazināšanos.
Darbs pie nātru klonēšana aizsācies jau 18.gadsimta sākumā, bet tas nav bijis īpaši sekmīgs. 20.gadsimta sākumā Dr. Gustavam Bredemannam izdodas radīt pirmos nātru klonus ar palielinātu šķiedru sastāvu. Šodien ar šāda veida zinātnisko darbu nodarbojas Vācijas, Austrijas, Somijas un arī citu valstu zinātnieki.
Latvijā ir ļoti maz vietējas izcelsmes šķiedru. Līdz ar to kā šī darba mērķis tika izvirzīts – izpētīt nātru kā tekstilizejmateriālu audzēšanas potenciālās iespējas.
Paraugi eksperimentāliem pētījumiem iegūti Lietuvas Lauksaimniecības un mežsaimniecības Upītes Eksperimentālajā centrā. Tur nātres izaudzētas no klonēto nātru spraudeņiem un eksperimentu vajadzībām uz lauka izstādītas 2007. un 2008. gadā, ievērojot atstarpes starp augiem 60x60cm un 60x100cm.
Eksperimentos noteikts, ka vidējais lūksnes sastāvs nātru stiebros ir ap 20%, kas salīdzinoši ir mazāks nekā linu un kaņepju stiebros. Tā kā arī nātru ražība nav tik liela kā iepriekš minētām šķiedrām, tad potenciāli nātres nevarētu dot tik lielu ekonomisko labumu kā linu vai kaņepju audzēšana, bet jāņem vērā, ka nātres vienreiz iestādītas, dotajā vieta aug 10 un pat 15 gadus, kā arī neprasa īpašu kopšanu.
Teorētiski rakstā apkopotas nātru šķiedru īpašības, bet praktiski noteikta šķiedru stiprība. No rezultātiem var secināt, ka vidējie rādītāji ir robežās no 33 – 58cN/tex. Relatīvā pārraušanas slodze lielāka ir ceturtā gada nātru šķiedrām, salīdzinot ar trešā gada šķiedrām. Šķiedru stiprību ietekmē arī augu stādīšanas blīvums. Secināts, ka pie mazākas atstarpes starp augiem, šķiedru stiprība ir augstāka. To var izskaidrot ar auga sazarošanās iespējām. Eksperimentāli atdalot šķiedras, konstatēts, ka tās visvājākās ir stumbra vietās, kur veidojušies zari.
Secināts, ka, neskatoties uz mazo šķiedru ražību, nātrēm varētu būt potenciālas audzēšanas iespējas Latvijā, jo tās neprasa pārāk lielu darbu, materiālos ieguldījumus, kā arī šķiedru kvalitāte ir apmierinoša.

Илзе Балтыня, Лилита Лапса, Зофия Янкаускиене, Элвира Груздевене. Волокна крапивы как потенциально возможное текстильное сырье в Латвии

Волокна крапивы уже давно использовались дня изготовления текстильных изделий. Главное внимание к ним было уделено во время кризисов и войн, когда не хватало других исходных материалов. Сегодня научные сотрудники снова уделяют внимание крапиве как культурному растению. Главным образом это связано с ростом применения биологически разлагаемых и вторично используемых волокнистых материалов, и также с ростом цен на синтетические волокна, что связано с уменьшением нефтяных ресурсов.

Работа над клонированием растений крапивы началась уже в начале 18-го века, но не была удачной. В начале 20-го века доктору Густаву Бредеманну удается создать первые клоны с повышенным содержанием волокна. В настоящее время этому вопросу уделено внимание ученых Германии, Австрии, Финляндии и других стран.

В Латвии немного местных исходных волокон. В связи с вышеупомянутым, целью данной работы было исследование возможности выращивания крапивы в Латвии. Опытные образцы были получены в Упитской опытной станции центра аграрных и лесных наук Литвы. Крапива выращена из черенков клонированной крапивы и высажена на поле в 2007 и 2008 году на расстоянии 60x60 и 60x100см.

Экспериментально определено, что среднее количество содержания луба около 20%. Это ниже, чем в таких лубяных растениях как конопля и лен. Так как урожайность крапивы ниже вышеуказанных волокон, казалось, что у волокон крапивы нет потенциальных экономических возможностей, но нужно учесть, что однажды посаженная крапива растет 10 и более лет на одном и том же месте, не требуя особого внимания.

В данной работе теоретически обобщены свойства волокон крапивы, экспериментально определены прочностные характеристики волокон. Средняя разрывная нагрузка от 33 – 58сН/текс. Прочность волокон, полученных от растений четвертого года, выше прочности волокон растений третьего года. На прочность также влияет плотность рассаживания саженцев. Чем меньше расстояние, тем прочнее волокна. Это можно объяснить возможностями разветвления веток. Экспериментально отделяя волокна, констатировано, что самая низкая их прочность в местах веток.

Учитывая вышесказанное, сделан вывод, что у крапивы есть потенциальные возможности использования ее в виде местного исходного текстильного сырья, так как ее производство не требует особых затрат и имеет удовлетворительное качество волокна.